75035

DRAFT

Ilmenite Basalt

1235 grams

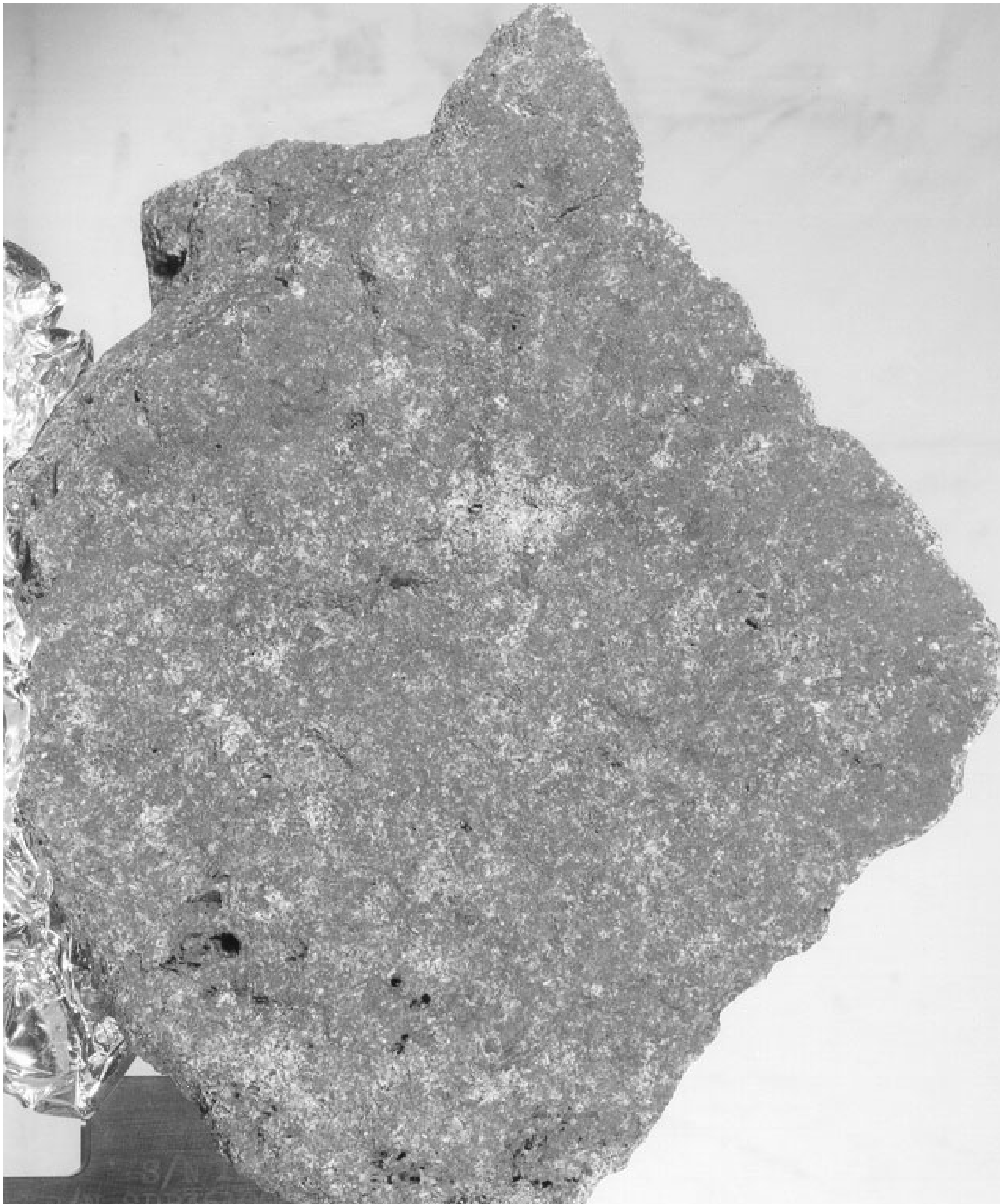

Figure 1: Photo of top, pitted side of 75035 showing micrometeorite pits. NASA S73-16257. Sample is 16 cm long.

Figure 2: Texture of 75035 showing plagioclase laths enclosed in pyroxene with ilmenite needles (taken from Neal and Taylor 1993). Scale 2.5 mm.

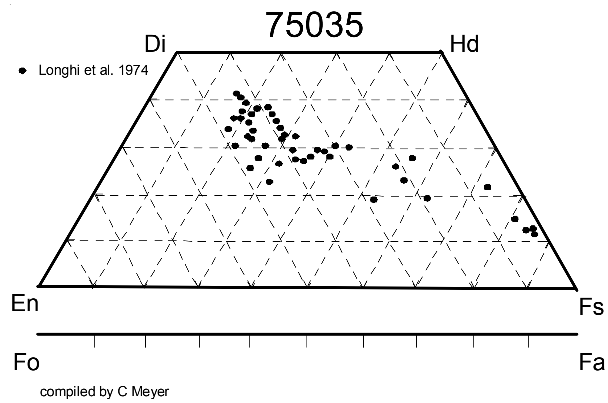

Figure 3: Pyroxene composition of 75035 (from Longhi et al. 1974).

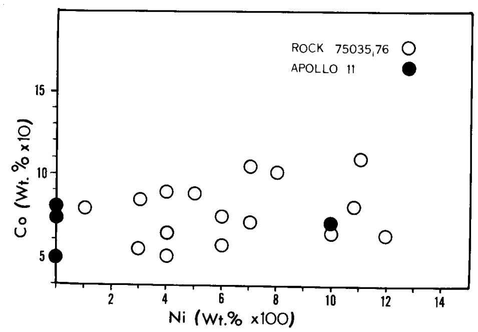

Figure 4: Ni and Co content of native iron in 75035 compared with Apollo 11 (this is figure 2 in Meyer and Boctor 1974).

Introduction

Lunar sample 75035 was collected from a small boulder on the rim of Camelot Crater and is presumed to represent a portion of a lava flow, deep beneath the regolith (Wolfe et al. 1981). This sample, along with 75015 and 75055 from the same location, is slightly more aluminous and less titanium rich, than other Apollo 17 basalts (Rhodes et al. 1976), and is surprisingly similar to some of the Apollo 11 basalts. It has the highest sulfur content (0.3 %) of any lunar sample.

The flat side of 75035 is pitted with micrometeorite craters and also shows about 2-3 % vugs or vesicles (figure 1). Zap pit are also found on the S, E and W sides. Surface photography allows orientation.

75035 has been dated at 3.76 b.y. with an ~80 m.y. exposure to cosmic rays.

Petrography

Longhi et al. (1974) found that 75035 was texturally and chemically like some of the Apollo 11 basalts (see also 75055). It is a medium-grained subophitic high-Ti basalt texturally similar to the Apollo 11 ophitic basalts (figure 2). Suhedral laths of plagioclase are surrounded by clumps of anhedral pyroxene. Large laths of ilmenite penetrate the plagioclase and pyroxene, providing evidence that ilmenite was the first phase to crystallize from the melt.

Mineralogical Mode of 75035

	Longhi et. al. 1974	Brown et al. 1975	Meyer and Boctor 1974
Olivine			
Pyroxene	44	45.4	45
Plagioclase	33	32.7	31
Ilmenite	15	13.8	17
Silica	5	6.2	5
Pyroxferroite	2		
Mesostasis	1	1.9	2

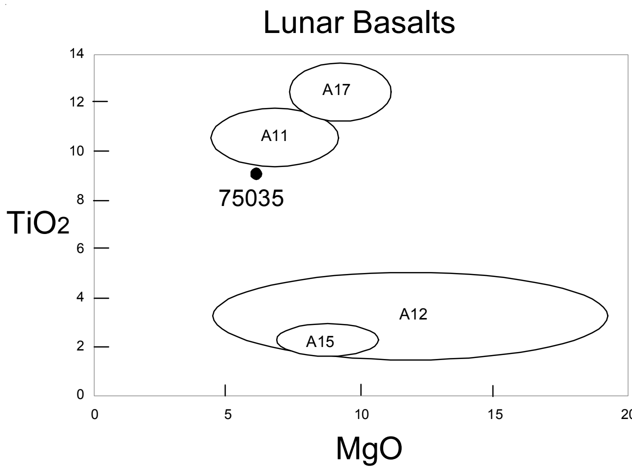

Figure 5: Composition of 75035 compared with other lunar basalts.

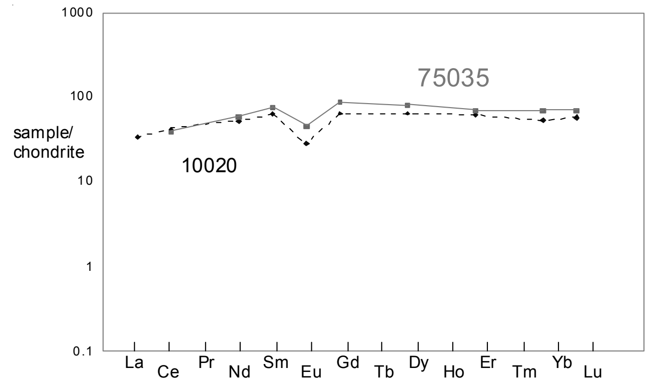

Figure 6: Normalized rare-earth-element diagram comparing 75035 with that of a typical Apollo 11 basalt (both determined by isotope dilution mass spectrometry Wiesmann et al 1975 and Philpotts et al. 1974).

Meyer and Boctor (1974) studied the minor phase in 75035 and Roedder and Weiblen (1975) studied melt inclusions in ilmenite from 75035. Metallic iron appears to have crystallized from the melt as a minor phase throughout the crystallization sequence.

Shih et al. (1975) and Rhodes et al. (1976) discuss the origin and differentiation of Apollo 17 basalts. 75035 appears to be the result of low pressure mineral separation and elemental fractionation of a more mafic parental magma.

Mineralogy

Pyroxene: Pyroxene crystals in 75035 are highly zoned. The composition of early formed pyroxene ($Wo_{40}En_{43}Fs_{15}$) varies continuously to pyroxferroite (figure 3). Some pyroxene crystals are sector-zoned. Jagodzinski et al. (1975) reported pigeonite exsolution from the augite cores.

Plagioclase: Plagioclase (An_{88-72}) grains up to 1.5 mm show iron enrichment during crystallization (Longhi et al. 1974).

Ilmenite: Ilmenite laths as big as plagioclase are abundant in 75035 (Meyer and Boctor 1974).

Cristoballite: 75035 has about 5% silica as a residual phase in the intersticies.

Metallic Iron: Meyer and Boctor (1974) found that metallic iron was associated with several accessory phases, and reported Ni and Co contents (figure 4). Iron grains were often associated with ulvospinel.

Troilite: Meyer and Boctor (1974) determined the Ti content of troilite

Tranquillityite: Careful analysis reported in Meyer and Boctor (1974).

Baddeleyite: Careful analysis reported in Meyer and Boctor (1974).

Zirconolite: Careful analysis reported in Meyer and Boctor (1974).

Chemistry

75035 is nearly identical in composition to Apollo 11 basalt (figures 5 and 6). Moore et al. (1974), Petrowski et al. (1974), Gibson and Moore (1974), Gibson et al. (1975), Moore (1975), Moore and Lewis (1976), Des Maris (1978) and Gibson et al. (1976) reported carbon, sulfur and nitrogen abundances. The sulfur content of 75035 (2770 ppm) is the highest recorded for any lunar sample (Gibson et al. 1976). Merlivat et al. (1974) determined the water content and isotopic ratio of hydrogen.

Radiogenic age dating

Murthy and Coscio (1976), Nunes et al. (1974), Turner et al. (1973) and Turner and Cadogen (1974) have each dated 75035 (figure 7-9). With an age of about 3.8 b.y., it is one of the oldest mare basalts – nearly as old as the Serenitatis Basin.

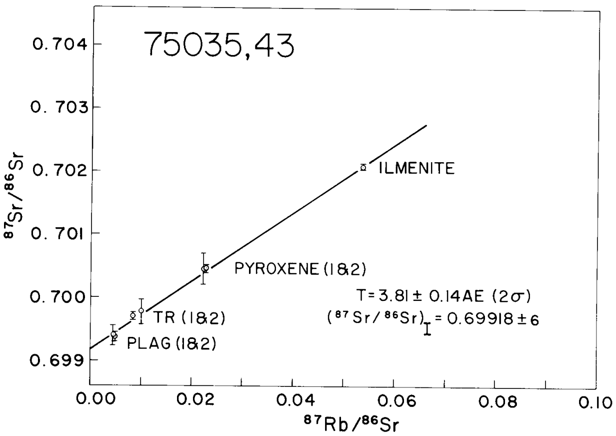

Figure 7: Rb/Sr mineral isochron for 75035 (from Murthy and Coscio 1976).

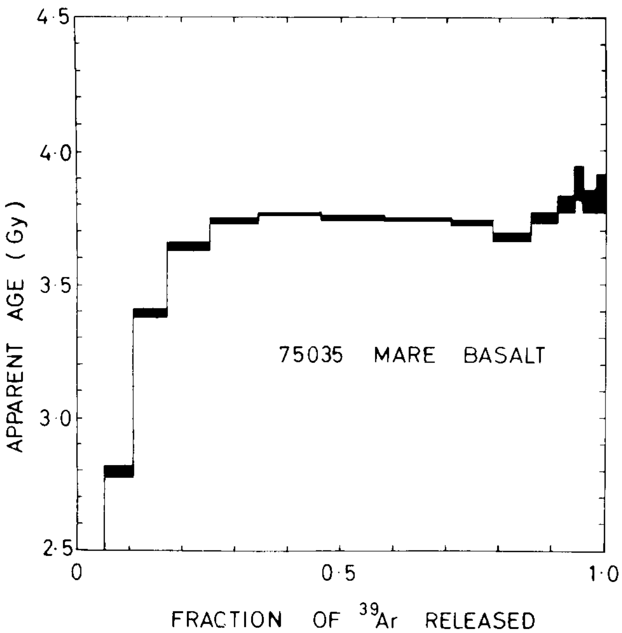

Figure 8: Argon release plateau for 75035 (from Turner and Cadogen 1974).

Tera and Wasserburg (1974) discuss the U/Pb age of 75035 and 75055 – giving an intercept age age of 4.42 b.y. (age of source region ?).

Summary of Age Data for 75035

	Pb/Pb	Rb/Sr	Ar/Ar
Nunes et al. 1974	3.56 ± 0.4 b.y.		
Murthy and Coscio 1976		3.81 ± 0.14	
Turner and Cadogen 1974			3.76 ± 0.05

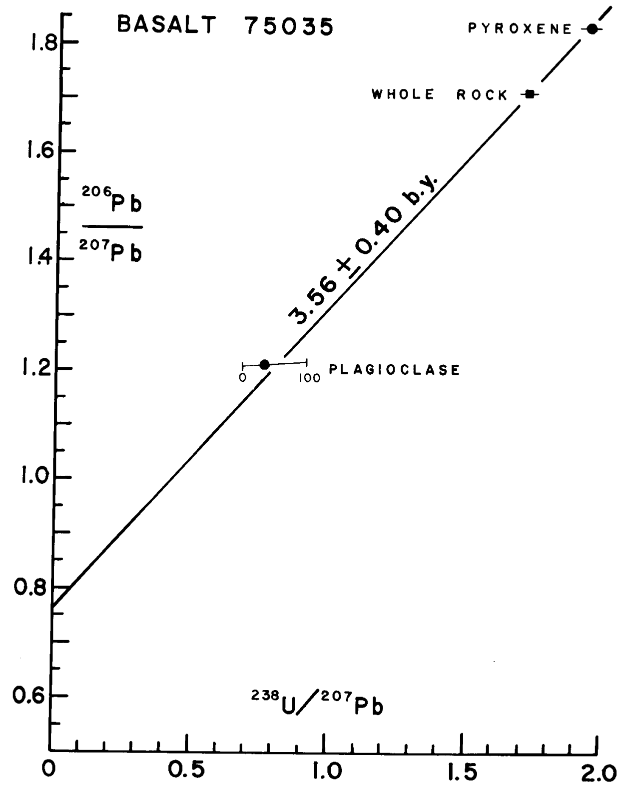

Figure 9: Pb/Pb age for 75035 (from Nunes et al. 1974).

Cosmogenic isotopes and exposure ages

Turner and Cadogen (1974) reported a cosmic ray exposure age of 80 m.y. determined by ^{38}Ar. Crozaz et al. (1974) and Arvidson et al. (1976) reported a cosmic ray exposure age of 75035 of 72 ± 2 m.y. by the ^{81}Kr method. Marti et al. (quoted by Bhandari et al. 1977) determined 89 ± 3 m.y. by ^{81}Kr. This gives the apparent age of Camelot Crater.

Crozaz et al. (1974) and Bhandari et al. (1977) reported a track ages of 7.3 m.y. and 5.4 m.y. respectively. These are understood to be low because of the constant erosion of the rock surface by micrometeorite bombardment. Based on their study of the incidence angle of fossil cosmic ray tracks in plagioclase, Kratschmer and Genter (1976), determined that 75035 probably had a “complex burial history”.

Yokoyama et al. (1974) determined that the surface of 75035 was “saturated” in ^{26}Al = 107 dpm/kg. (^{22}Na = 170 dpm/kg.)

Other Studies

The results obtained on 75035 are reviewed in the catalog by Neal and Taylor (1993).

Table 1a. Chemical composition of 75035.

reference	Laul 74	Brunfelt74		Rose75		Wanke75		Duncan76		Murthy76		Philpotts74		Garg78		
weight	286 mg															
SiO2 %				42.61	(c)			42.31	(d)							
TiO2	9	9.2	(a)	9.59	(c)	9.98	(a)	8.95	(d)							
Al2O3	9.9	9.7	(a)	10.05	(c)	9.24		10.3	(d)							
FeO	18.8	18.4	(a)	18.08	(c)	19.22		18.57	(d)					17.62		(a)
MnO	0.236	0.25	(a)	0.27	(c)	0.269		0.262	(d)							
MgO	7	6.8	(a)	6.25	(c)	6.13		6.28	(d)							
CaO	11.3	10.6	(a)	12.53	(c)	11.69		12.15	(d)							
Na2O	0.42	0.404	(a)	0.39	(c)	0.46		0.53	(d)							
K2O	0.074	0.069	(a)	0.08	(c)	0.084		0.061	(d)	0.073	(b)	0.066	(b)			
P2O5				0.06	(c)	0.09		0.084	(d)							
S %						0.14		0.219	(d)							
sum																
Sc ppm	76	82	(a)	74	(c)	83.6								79.3		(a)
V	30	30	(a)	16	(c)											
Cr	1512	1070	(a)	1780	(c)	1608		1416	(d)					1380		(a)
Co	16	13.7	(a)	18	(c)	14.5		19	(d)					16.6		(a)
Ni		<10	(a)	11	(c)			13	(d)							
Cu		3.8	(a)	32	(c)	3.34										
Zn		2	(a)	4.6	(c)	2.1										
Ga		4.5	(a)	6.2	(c)	3.95										
Ge ppb						<20										
As						1										
Se						<0.08										
Rb		0.6	(a)			0.81		1.5	(d)	0.655	(b)	0.679	(b)			
Sr		195	(a)	186	(c)	209		223	(d)	189.5	(b)	192	(b)			
Y				104	(c)	105		118	(d)							
Zr				255	(c)	300		319	(d)					437	336	(a)
Nb						24		29	(d)							
Mo																
Ru																
Rh																
Pd ppb																
Ag ppb																
Cd ppb																
In ppb																
Sn ppb																
Sb ppb																
Te ppb																
Cs ppm		0.04	(a)			0.026										
Ba	95	81	(a)	224	(c)	102		126	(d)	86.5	(b)	92.9	(b)			
La	7.3	7.6	(a)			9.07										
Ce	27	20.4	(a)			35						23.6	(b)			
Pr						6.5										
Nd	30		(a)			36.5						27.3	(b)			
Sm	10.8	12.9	(a)			13.6						11.2	(b)			
Eu	2.2	2.25	(a)			2.6						2.52	(b)	2.02		(a)
Gd						19.8						17.1	(b)			
Tb	3.1	2.81	(a)			3.8								1.5		(a)
Dy	20	22.9	(a)			24						19.7	(b)			
Ho						4.8										
Er						15						11.1	(b)			
Tm																
Yb	10	10.7	(a)	10	(c)	13.2						11.4	(b)			
Lu	1.5	1.82	(a)			1.88						1.7	(b)			
Hf	8.7	10	(a)			11.2								13.6	11.4	(a)
Ta	1.6	1.81	(a)			2.01										
W ppb		0.12	(a)			0.085										
Re ppb						<0.2										
Os ppb																
Ir ppb																
Pt ppb																
Au ppb						0.033										
Th ppm	0.3	0.35	(a)													
U ppm		0.113	(a)			0.149										

technique: (a) INAA, (b) IDMS, (c) mixed, (d) XRF

Crozaz et al. (1974) determined the isotopic ratios of Xe and Kr.

Lugmair and Marti (1978) presented Sm and Nd isotope data in a diagram.

Turner and Cadogen (1974) used 75035 to evaluate the role of Ar recoil effects that might effect age dating plagioclase. Schaeffer et al. (1977) used 75035 to try to understand how a laser probe might be used to date an igneous rock of known age (they obtained a range of ages). Schaeffer et al. showed that Ar recoil effects are often confused with diffusion loss of Ar from high K phases. *Note*: Horn et al. (1975) used 75075 to investigate the effects of recoil on Ar/Ar ages.

Pearce et al. (1974), Brecher (1977) and Sigiura et al. (1979) determined the magnetic properties of 75035.

Longhi et al. (1974) and O'Hara and Humphries (1975) determined the low pressure phase diagram for Apollo 17 basalts, including 75035. Taylor and Williams (1974) and Usselman et al. (1975) determined the cooling rate of the sample. McCallum and Charette (1977, 1978) determined the crystal/liquid distriburtion coefficients of Zr and Nb for ilmenite, armalcolite and clinopyroxene. Longhi et al. (1978) experimentally studied the Fe/Mg partitioning between olivine and melt using 75035 (*although the rock itself has no olivine*).

Schaal and Horz (1977), Schaal et al. (1979) and Harrison and Horz (1981) reported studies of shock metamorphism of basalt using samples of 75035 as starting material.

Petrowski et al. (1974) and Gibson et al. (1975) determined the isotopic composition of carbon and sulfur in 75035.

<u>Processing</u>

In 1973, 75035 was sawn to create a slab (figure 10). However, the orientation of the columns cut from this slab do not appear to be normal to the lunar surface orientation.

75035 is used for public display, including a small piece for the Astronaut Ambassador Program.

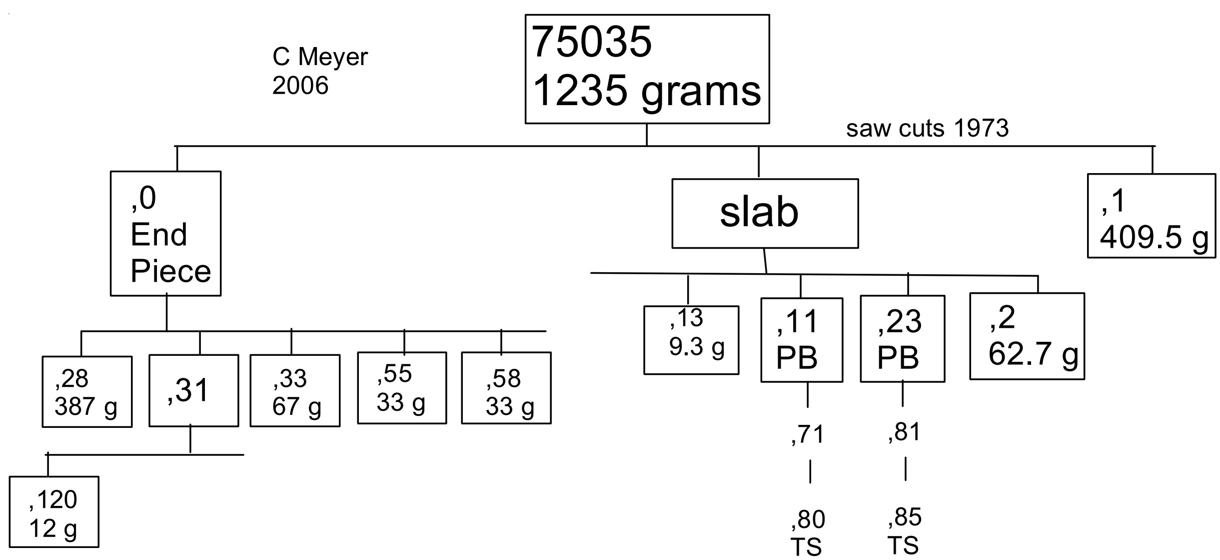

Table 2	U ppm	Th ppm	K ppm	Rb ppm	Sr ppm	Nd ppm	Sm ppm	technique
Murthy and Coscio 1976			604	0.655	189.3			idms
Yokoyama et al. 1974 (top)	0.22	0.65						counting
Nunes et al. 1974	0.151	0.4879						idms
Brunfelt et al. 1974	0.113	0.35		0.6	195			inaa
Philpotts et al. 1974				0.679	192	27.3	11.2	idms
Wanke et al. 19754	0.149				36.5	13.6		inaa

Figure 10: Group photo of end pieces and sawn slab of 75035. NASA S73-31796. Small cube is 1 cm.